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IN THE APPLICATION

OF

TED S. FASCA

FOR AN

ENERGY STORAGE SYSTEM AND METHOD

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ENERGY STORAGE SYSTEM AND METHOD

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application Serial No. 60/415,750, filed October 4, 2002, which is herein incorporated by reference.

1. FIELD OF THE INVENTION

The present invention relates to a device and method for storing energy during an off-peak period and distributing and/or selling energy during a peak period in a wholesale energy market.

2. DESCRIPTION OF RELATED ART

Deregulation of the energy market has led to the development of wholesale energy markets in which energy producers pool together their supplies of energy, form a market, determine a price for energy, and sell the energy to energy consumers. In a typical wholesale energy market, such as the PJM Interchange (formerly known as the Pennsylvania-New Jersey-Maryland Interchange), there are three main types of power

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generation: fossil fuel, nuclear and renewable. Fossil fuel power generation includes coal, gas and oil powered plants. Renewable power generation includes hydro, solar and wind powered plants. 79% of the U.S. wholesale energy market is supplied by fossil fuel sources, 20% by nuclear and 1% by renewable sources. Power is produced and supplied to the wholesale energy market as needed. Power production is increased during peak hours and decreased during off-peak hours.

Base load units, such as coal fired plants, must run continuously because the cost of shutting down and starting up the units are prohibitively high. Because demand for power is low during the off-peak period, not all of the power produced by the base load units is consumed. Further, in the wholesale energy market, the power that is purchased during the off-peak period must be sold at a market price. The market price is typically lower than the cost to produce the power. Therefore, power producers in the wholesale energy market must operate their base load units at a loss during the off-peak period.

While a variety of devices have been proposed for storing energy, none have been provided for use in the wholesale energy market. There is a need for an energy storage system and/or method for storing energy during an off-peak period and distributing energy during a peak period in a wholesale market.

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The related art is represented by the following references of interest.

U.S. Patent Application Publication No. 2001/0010222 A1, printed on August 2, 2001 for Melvin L. Prueitt, describes a solar power generation and energy storage system. The Prueitt application does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent Application Publication No. 2002/0000306 A1, published on January 3, 2002 for James E. Bradley, describes methods and devices for storing energy utilizing phase change material. The Bradley application does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent Application Publication No. 2002/0041126 A1, published on April 11, 2002 for John H. Provanzana et al., describes a power load-leveling system and packet electrical storage utilizing capacitors. The Provanzana et al. application does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 4,532,769, issued on August 6, 1985 to Lyle A. Vestermark, describes an energy storing flywheel assembly in which first and second reels are operatively connected by a flexible band, with the first and second reels capable of being rotated by first and second electric motors, and the second reel that can rotate either clockwise or counter clockwise through a

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clutch mechanism driving a flywheel. The Vestervark patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,093,770, issued on March 3, 1992 to John L. Davenport, describes an electrical energy storage system for altering the state of a magnetic actuator in order to effect the opening or closing of an associated circuit breaker. The Davenport patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,200,687, issued on April 6, 1993 to Jonas Lindblom et al., describes an energy storage system for use in a receptacle having terminals connected to conductors for establishing an electric circuit. The Lindblom et al. patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,368,957, issued on November 29, 1994 to Ivan D. Kozmik et al., describes an energy storage device with novel cathode materials. The Kozmik et al. patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,373,195, issued on December 18, 1994 to Rik W.A.A. De Doncker et al., describes a technique for decoupling the energy storage system voltage from the DC link voltage in AC electric drive systems. The De Doncker et al.

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patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,589,727, issued on December 31, 1996 to D. Clint Seward, describes an energy storage device in which a vacuum tube and a magnetic field are used to store electrons circulating within the tube along spiral paths. The Seward patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,093,770, issued on March 3, 1992 to John L. Davenport, describes an electrical energy storage system for altering the state of a magnetic actuator in order to effect the opening or closing of an associated circuit breaker. The Davenport patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,590,568, issued on January 7, 1997 to Muneaki Takara, describes a device for rotating a layered body that includes multiple rotating plates arranged in equally spaced layers and coaxially aligned about an axis of rotation. The Takara patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,610,802, issued on March 11, 1997 to Phillip A. Eidler et al., describes an energy storage system including a housing adapted to rest on a supporting surface.

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The Eidler et al. patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,614,777, issued on March 25, 1997 to Jack G. Bitterly et al., describes a high speed rotating flywheel and an integral motor/generator unit. The Bitterly et al. patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,655,617, issued on August 12, 1997 to Herbert K. Marshall, describes an elastomeric energy storage system. The Marshall patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,931,249, issued on August 3, 1999 to Christopher W.H. Ellis et al., describes a kinetic energy storage system which utilizes a flywheel with a motor generator to store energy. The Ellis et al. patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,936,375, issued on August 10, 1999 to Masamitsu Enoki, describes a method for energy storage and recovery for load hoisting equipment driven by an inverter controlled first induction motor and having a second inverter controlling a second induction motor with drives a flywheel. The Enoki patent does not suggest an energy storage system and/or method according to the claimed invention.

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U.S. Patent No. 5,939,798, issued on August 17, 1999 to Nicholas W. Miller, describes an energy storage system including a first power conversion device and a second power conversion device for providing energy to loads upon interruption of a main power source. The Miller patent does not suggest an energy storage system and/or method according to the claimed invention.

U.S. Patent No. 5,948,562, issued on September 7, 1999 to Michael Fulcher et al., describes electrochemical cells packaged in flexible foil laminate packages. The Fulcher et al. patent does not suggest an energy storage system and/or method according to the claimed invention.

European Patent Application Publication No. 0 511 829 A2, published, describes an energy storage system for receiving and storing electrical power and releasing the power to an electric circuit. The European '829 application does not suggest an energy storage system and/or method according to the claimed invention.

None of the above inventions and patents, taken either singly or in combination, is seen to describe the instant invention as claimed. Thus an energy storage system and method solving the aforementioned problems is desired.

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SUMMARY OF THE INVENTION

The present invention is an energy storage system and method for storing energy during an off-peak period and distributing energy during a peak period in a wholesale energy market. An energy storage system according to the invention includes a first energy directing device for directing energy produced in the wholesale energy market during the off-peak period into an energy storage device, and a second energy directing device for directing the energy from the energy storage device into the wholesale energy market during the peak period.

A method according to the invention produces energy in the wholesale energy market during the off-peak period, directs the produced energy into an energy storage device, stores the produced energy in the energy storage device, and directs the stored energy from the energy storage device into the wholesale energy market during the peak period.

A method for creating profit in a wholesale energy market according to the invention produces energy in the wholesale energy market during the off-peak period at an off-peak period price, directs the produced energy into an energy storage device, stores the produced energy in the energy storage device, directs the stored energy from the energy storage device into

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the wholesale energy market during the peak period, and sells the stored energy directed to the wholesale energy market at a peak period price.

Accordingly, it is a principal aspect of the invention to provide a system for storing energy during an off-peak period and distributing energy during a peak period in a wholesale energy market.

It is another aspect of the invention to provide a method of storing energy during an off-peak period and distributing energy during a peak period in a wholesale energy market.

It is a further aspect of the invention to provide a method for creating profit in a wholesale energy market.

It is an aspect of the invention to provide improved elements and arrangements thereof in an energy storage system and method for the purposes described which is inexpensive, dependable and fully effective in accomplishing their intended purposes.

These and other aspects of the present invention will become readily apparent upon further review of the following specification and drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is schematic view of a device for storing energy during an off-peak period and distributing energy during a peak period in a wholesale energy market according to the present invention.

Fig. 2 is a flow chart of a method of storing energy during an off-peak period and distributing energy during a peak period in a wholesale energy market.

Fig. 3 is a flow chart of a method for creating profit in a wholesale energy market.

Fig. 4 is a schematic view of various types of energy storage devices.

Fig. 5 is a schematic view of a mechanical potential energy storage system in a lowered position.

Fig. 6 is a schematic view of a mechanical potential energy storage system in a raised position.

Fig. 7 is a chart showing the average hourly Locational Market Price (LMP) for energy in the Potomac Electric Power Company (PEPCO) Zone of the PJM Interchange, which is one example of a wholesale energy market.

Similar reference characters denote corresponding features consistently throughout the attached drawings.

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DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is an energy storage system and method for storing energy during an off-peak period and distributing energy during a peak period in a wholesale energy market. The invention disclosed herein is, of course, susceptible of embodiment in many different forms. Shown in the drawings and described herein below in detail are preferred embodiments of the invention. It is to be understood, however, that the present disclosure is an exemplification of the principles of the invention and does not limit the invention to the illustrated embodiments.

The present invention is directed to a system **10** for storing energy during an off-peak period and distributing energy during a peak period in a wholesale energy market (see **Figs. 1, 5** and **6**). The present invention is also directed to a method of storing energy **200-230** during an off-peak period and distributing energy during a peak period in a wholesale energy market (see **Fig. 2**), and a method for creating profit **300-340** in a wholesale energy market (see **Figs. 3** and **7**).

Fig. 7 shows the average hourly LMP for energy in the PEPCO Zone of the PJM Interchange, which is one example of a wholesale energy market. Price is expressed in terms of dollars per megawatt hour ($/MWHr) and includes average hourly prices for each year from 1998 to 2001. The off-peak period price **P1** for

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energy during the off-peak period **T1** in the wholesale energy market **100** is much lower than the peak period price **P2** during the peak period **T2**. The present invention is directed toward a system and method for producing and storing energy during the off-peak period and distributing or selling the stored power during the peak period at a higher price.

As shown in **Fig. 1**, an energy producer **110** creates usable energy and directs it to the wholesale energy market **100** via a first means of transmission, such as first transmission lines **115**. The energy producer **110** may be any type of electric power generator such as a nuclear, coal, gas, oil, hydro, wind or solar electric power generator. The wholesale energy market **100** directs the energy to an energy consumer **120** via a second means of transmission, such as second transmission lines **125**. The energy consumer **120** may be any kind of electric power consumer, such as a residential, commercial or industrial consumer or another wholesale energy market. The first and second means of transmission could be any suitable device for transmitting energy from the energy producer **110** to the wholesale energy market **100** and from the wholesale energy market **100** to the energy consumer **120**.

The system **10** of the present invention receives energy either from the wholesale energy market **100** or directly from the energy producer **110** via a first means of directing energy. The

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first means of directing energy may be any suitable device for transmitting energy, such as electric transmission lines **20, 25**. If, for example, the energy is to be provided from the wholesale energy market **100**, the energy may be transmitted to the system **10** via electric transmission lines **20**. If the energy is to be provided directly from the energy producer **110**, the energy may be transmitted to the system **10** via electric transmission lines **25**.

The first means of directing energy is provided for directing energy produced in the wholesale energy market **100** or by the energy producer **110** during an off-peak period **T1** into a means for storing energy **50**. The off-peak period **T1** is the period of time during which demand for energy and energy prices are comparatively low. For example, as shown in **Fig. 7**, the off-peak period **T1** may be the eight hour time period from 12 midnight to 8 a.m. However, the off-peak period **T1** may be a shorter or longer period of time depending on the particular supply and demand of the wholesale energy market **100**. The means for storing energy **50** will be discussed in greater detail below.

The system **10** has a second means of directing energy for directing the energy from the means for storing energy **50** to the wholesale energy market **100** during a peak period **T2**. The second means of directing energy may be any suitable device for transmitting energy, such as electric transmission lines **80, 85**.

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If, for example, the energy is to be directed to the wholesale energy market **100**, the energy may be supplied from the system **10** via electric transmission lines **80**. If the energy is to be directed directly to the energy consumer **120**, the energy may be supplied from the system **10** via electric transmission lines **85**. The peak period **T2** is the period of time during which demand for energy and energy prices are comparatively high. For example, as shown in **Fig. 7**, the peak period **T2** may be the sixteen hour time period from 8 a.m. to 12 midnight. However, the peak period **T2** may be a shorter or longer period of time depending on the particular supply and demand of the wholesale energy market **100**.

As shown in Fig. **4**, the means for storing energy **50** may be a pumped hydropower system **51**, a compressed air energy storage (CAES) system **52**, a battery system **53**, a flywheel system **54**, a superconducting magnetic energy storage (SMES) system **55**, a supercapacitor system **56**, a thermal energy storage system **57**, for example, using molten salt, or a mechanical potential energy storage system **400**. All of these systems store energy by converting electric energy into another form of energy, and then converting the other form of energy back into electric energy.

As shown in **Figs. 5** and **6**, the means for storing energy **50** may be provided as a mechanical potential energy storage system **400**. The mechanical potential energy storage system **400**

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may be provided, for example, with a mass **410**, a means for lifting the mass **410**, and a means for lowering the mass **410**. The means for lifting the mass **410**, and the means for lowering the mass **410** may be any suitable device for lifting the mass **410**.

For example, the mass **410** may be lifted and lowered using a motor **30** connected to the mass **410** with a first cable **40**. The first cable **40** may be attached to a pulley **420**. The mass **410** is also connected to a generator **70** using a second cable **60**, which may also be attached to the pulley **420**. In operation, the mass **410** starts in a lowered position, as shown in **Fig. 5**. During the off-peak period **T1**, the motor **30** lifts the mass **410** with the means for lifting using the energy produced during the off-peak period **T1** to create a potential energy. The mass **410** is then in a raised position, as shown in **Fig. 6**. During the peak period **T2**, the mass **410** is lowered with the means for lowering thereby supplying the second means for directing energy **80, 85** with energy. The mass **410** returns to the lowered position, as shown in **Fig. 5**.

The structure of the mechanical potential energy storage system **400** used to support the weight of the mass **410** may be, for example, a metal or concrete structure. There could be a single motor **30** and a single generator **70**, or a plurality of motors and generators, as appropriate. The motor and generator

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could be separate devices or they may be provided in a single apparatus that is a combination motor/generator. In order to provide enough potential energy storage to be of use in the wholesale energy market **100**, the mass **410** may be a single, large mass or a plurality of masses. The total mass for a device for use in the wholesale energy market is on the order of several thousand tons, and the mechanical potential energy storage system **400** is adapted to accommodate the forces which correspond with such a mass.

As shown in **Fig. 4**, the mechanical potential energy storage system **400** may be a pulley and cable system **500**, a block and tackle system **510**, a chain pull system **520**, or a hydraulic system **530**. All of these systems store energy in a manner similar to the manner described above and shown in **Figs. 5** and **6**. The hydraulic system **530** does not require cables or pulleys to lift the mass, but includes the motor **30** and generator **70**.

As shown in **Fig. 2**, the present invention is also directed to a method **200-230** of storing energy during an off-peak period **T1** and distributing energy during a peak period **T2** in the wholesale energy market **100**. The method **200-230** has the steps of producing energy **200** in the wholesale energy market **100** during the off-peak period **T1**, a first directing step **210** of directing the energy produced in the producing step **200** into a

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means for storing energy **50**, storing **220** the energy in the means for storing energy **50**, and a second directing step **230** of directing the energy from the means for storing energy **50** into the wholesale energy market **100** during the peak period **T2**. The means for storing energy **50** of the method **200-230** may be provided in any of the embodiments described above.

As shown in **Figs. 3** and **7**, the present invention is also directed to a method **300-340** for creating profit in the wholesale energy market **100**. The method **300-340** has the steps of producing energy **300** in the wholesale energy market **100** during an off-peak period **T2** at an off-peak period price **P1**, a first directing step **310** of directing the energy produced in the producing step **300** into a means for storing energy **50**, storing **320** the energy in the means for storing energy **50**, a second directing step **330** of directing the energy from the means for storing energy **50** into the wholesale energy market **100** during a peak period **T2**, and selling **340** the energy at a peak period price **P2**. The means for storing energy **50** of the method **300-340** may be provided in any of the embodiments described above. For example, the LMP averages about $15/MWHr hour during the off-peak period **T1** and $37/MWHr during the peak period **T2**. Given these parameters, the present invention would provide a gross profit of $22/MWHr.

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The methods **200-230** and **300-340** may have the further steps of lifting the mass **410** with the motor **30** and the means for lifting using the energy produced during the off-peak period **T1** thereby creating a potential energy, and powering the generator **70** during the peak period **T2** with the potential energy when the mass **410** is lowered with the means for lowering.

While the invention has been described with references to its preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teaching of the invention without departing from its essential teachings.

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